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Agricultural Research

Research Pays Its Way

In my meetings with farm groups and other organizations over the past few years, I have pointed out that investment in agricultural research is a wise and prudent commitment of public funds. In fact, investment in agricultural research often pays spectacular dividends.

Most estimates made of the rate of return to investment in agricultural research over the past three decades range between 35 and 45 percent each year. And for the last 5 years, analysis of agricultural production figures shows a rate of return on investment even higher than 45 percent. It is hard to imagine any investment—either public or private—that consistently produces such favorable rates of return.

Vernon Ruttan, the distinguished agricultural economist and 1983 Morrison Lecturer, assures me that the methodology for developing estimates continues to evolve. He advises that precise estimates must be used with some caution.

Agricultural economists have developed two methods to study the contributions of research to increased agricultural productivity. In one method, the index number approach, the estimates are computed directly from the costs and benefits of research on a specific commodity.

The second method, called regression analysis, estimates the incremental return from increased investment rather than the average return from all investment.

Using the regression analysis method, research is credited with a 65-percent annual rate of return during the period from the founding of the Department of Agriculture in the 1860's to 1926.

From 1927 to 1950, research was divided into two categories. The first was technology oriented—research in which new technology was the primary objective. The second category was science oriented—answering scientific questions related to the production of new technology. From 1927 to 1950, technology-oriented research yielded an annual rate of return of 95 percent. During the same 23 years, science-oriented research yielded a 110-percent annual rate of return.

It's important to keep in mind that the two decades from 1927 to 1950 were a period of dramatic progress in the agricultural sciences. These were the years of hybrid corn, major improvements in the nutrition of plants and animals, and strides in veterinary medicine. It was also a period of rapid mechanization on the farm and dramatic growth in postharvest technology.

Throughout the two decades from 1950 to 1971, technology research continued to yield annual returns of over 90 percent. Science-oriented agricultural research remained profitable as it interacted with technological research, but it was less profitable than during the 1927 to 1950 period.

Three examples—outstanding successes each—clearly demonstrate the return on investment for the public good.

The first example, a vaccine against Marek's disease, has already saved the U.S. poultry industry $2 billion.

In 1971, the first year the ARS-developed vaccine for Marek's disease was made available for national use, benefits from the vaccine amounted to $30 million. This meant that in 1 year, the benefits had paid back nearly all of the total 10-year research cost of $32 million.

By 1974, the first year of full adoption of the vaccine by the poultry industry, gross benefits had climbed to $628 million. Since then, net benefits stemming from the use of the vaccine are estimated at $168 million annually.

The second example is more speculative. It concerns a 150-foot-long, 2-story pilot plant that automates the tanning of cattle hides. This ARS-produced technology should help U.S. tanners compete in the world market. Presently, exported cattle hides produce approximately $1 billion of foreign currency to help offset the balance of payments. If these hides were converted to finished leather before export, using new, more efficient procedures, their market value would be doubled.

The final example concerns a small stingless wasp imported from Europe. These insects saved U.S. farmers throughout the East and Midwest $29 million during the past 9 years by protecting alfalfa fields from the alfalfa blotch leafminer. Since first released, the wasps have overtaken and killed fast-spreading leafminer populations from the Canadian Maritime Provinces to Virginia and west to Michigan. In 1984, the buildup of wasps was sufficient to prevent damage estimated at $13 million to alfalfa crops in 10 states.

These examples are just the tip of the iceberg. There are many other equally fascinating success stories that quantify the impact of ARS research upon America's agricultural industry.

Terry B. Kinney, Jr.
Administrator

Agricultural Research

At ARS' National Soil Erosion Laboratory, West Lafayette, IN, scientist Mark Nearing studies the resistance of soil to the impact of a single raindrop falling from a 40-foot-high tower. The 3-year-old laboratory provides "a center and a focus" for the Department of Agriculture's soil erosion in the midwest. Story on p. 8. (1183X1567-15A)

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Gene Find May Overcome Resistance

The red flour beetle, which infests stored grain and grain products, is showing marked resistance to malathion, the most commonly used insecticide for stored grain.

"Resistance has intensified throughout the grain and peanut-growing belts in the United States in the past 15 years," says ARS entomologist Richard W. Beeman, whose research is aimed at reversing the trend.

In studies at the U.S. Grain Marketing Research Laboratory, Manhattan, KS, more than 100 strains of 5 important genera of beetles were collected from corn, wheat, and oat storage bins in 14 grain-producing states.

Beeman and graduate research assistant Jonathan P. Haliscak, Kansas State University, found 31 strains of red flour beetle, *Triboleum castaneum* (Herbst), that showed detectable levels of resistance. Only five strains were killed by malathion at doses usually lethal to red flour beetles, Beeman says.

First-generation progeny of malathion-resistant strains showed increased resistance, he said. They survived malathion treatments up to 20 times greater than doses that would have killed their parents.

Resistance in red flour beetle populations is increasing in most areas. However, on a national scale, more severe resistance has been recorded in Alabama, Florida, and Georgia than in the north-central regions, Beeman says.

Beeman has located the gene in red flour beetles that gives resistance to malathion and is now trying to pinpoint genes that resist such other chemicals as DDT, heptachlor, and related insecticides.

He says the red flour beetle is a logical candidate for evaluating the subtle or long-term effects of manipulating genes because the insect is easy to rear and to handle and has a long reproductive life.

The red flour beetle is the only Coleoptera—order of insects that includes beetles and weevils—that shows promise for supplying extensive genetic information on insecticide resistance. Major genes have been located and mapped previously only in Diptera (flies and mosquitoes) and in Orthoptera (cockroaches).

Such genetic information would enable us to detect and recover radiation-induced chromosomal aberrations that might, in turn, be used to introduce insecticide susceptibility or other desirable genes into natural populations, Beeman says.

In the other four stored-grain pests evaluated by the scientists—lesser grain borer, flat and rusty grain beetle, sawtoothed and merchant grain beetle, and weevil—only the lesser grain borer, a major pest of wheat, showed resistance comparable, although to a lesser degree, to that of the red flour beetle.

Malathion, registered for post-harvest insect control by the Federal Drug Administration in 1958, has been the primary residual insecticide used to treat stored grain in the United States since that time.—**Betty Solomon**, Peoria, IL.

Richard W. Beeman is located at the U.S. Grain Marketing Research Laboratory, 1515 College Ave., Manhattan, KS 66502. ■

Blueberries ripen under Michigan sun. (0874X1410-14A)

Fluorescent Stain Sure Test For Blueberry Disease

Blue pinpoints of light glowing from a sliver of root reveal tiny parasites smaller than bacteria hidden in the food transport cells of blueberry plants.

The parasites, known as mycoplasmalike organisms, are infecting nursery stock tested by ARS plant pathologist Richard H. Converse.

A new staining technique with diamidino phenylindole—DAPI for short—causes the organism's DNA to fluoresce brightly under ultraviolet light, Converse says.

Because they glow so brightly with DAPI, it is possible to estimate the severity of an infection, he says, something which couldn't be done readily with an electron microscope or other stains.

Ranging between a virus and a bacterium in size, the parasites cause blueberry stunt, the most serious disease of blueberries in the northeastern United States, plus a host of other viruslike diseases found in strawberries, raspberries, blackberries, blueberries, and cranberries.

The mycoplasmalike organisms are found throughout the plant, although concentrations are usually higher in the roots, Converse says.

DAPI can dramatically shorten

testing time, Converse says. An experienced technician can stain and evaluate 150 to 200 root tissue samples a week, but only 15 to 20 using other techniques.

Converse and Ulrike Schaper, research associate with Oregon State University's Department of Botany and Plant Pathology (she is now at the University of North Carolina) found the DAPI technique much more accurate than existing tests, such as with aniline blue.

"DAPI detected 96 percent of the infected laboratory samples contrasted with 76 percent for aniline blue," Converse says. "The problem with aniline blue is that it detects a product the plant makes in response to disease rather than the actual disease organism."

The new staining technique was even better at picking disease-free samples. It found 100 percent of the samples known to be free of the mycoplasmalike organisms. Converse expects that this feature—identifying disease-free nursery stock—will be an important use for the new test.—**Howard Sherman**, Albany, CA.

Richard H. Converse is located at the Horticultural Crops Research Laboratory, 3420 Southwest Orchard St., Corvallis, OR 97330. ■

Fire Ants Prey on Mosquitoes

Is there anything good to say about a fire ant? "Maybe," says ARS entomologist James W. Summerlin. "The red imported fire ant evidently helps control at least six species of woodland mosquitoes."

The scientist reports that the mosquitoes are the kind that breed in rot holes and fork hollows of southern trees.

"They are hard to control because their breeding places are usually hidden or inaccessible. But where fire ants also infest the area, they often fill tree holes with nesting soil. That prevents the accumulation of water and keeps mosquitoes from breeding.

Summerlin adds that there are also reports that fire ants feed on mosquito eggs and on the larvae of horn fly, a pest of cattle.

"The fire ant preys on so many insects," remarks Summerlin, "that inevitably it eats some that are harmful to man and his livestock. That's not because the fire ant is helpful, but because it's such a ferocious predator."—**Bennett Carriere**, New Orleans, LA.

James W. Summerlin is located at the Veterinary Toxicology and Entomology Laboratory, P.O. Box GE, College Station, TX 77841. ■

Forage Plant Rids Soil of Sodium

A plant that alters soil to suit itself may spell relief for farmer-ranchers with salt-bound soils in the arid Southwest and similar areas throughout the world.

Last April, ARS soil scientist Charles W. Robbins and his co-workers, at Kimberly, ID, made a fortuitous find. While collecting data on the ability of roots of certain plants to produce carbon dioxide, they discovered Sordan grass was releasing 2 to 2½ times more carbon dioxide into the soil than cotton, barley, alfalfa, or tall wheatgrass. Sordan is a sorghum-sudangrass hybrid used for livestock forage.

The significance of Sordan's elevated output is in carbon dioxide's ability to form carbonic acid in moist soil, which in turn dissolves lime or calcium carbonate in the soil. When calcium is in solution, it replaces the unwanted sodium attached to the clay in the soil. The released sodium can then be leached out by irrigation. After leaching, the soil can be planted to crops less salt tolerant than Sordan.

Saline or high-sodium soils severely limit one's choice of crops, Robbins says. Most plants cannot extract water from a salt system. When sodium builds up—either because rainfall is unavailable or insufficient to flush out salts as they weather out of minerals—soil collapses, seals up, and loses its permeability to air and water.

"To test the implications of our discovery," says Robbins, "we planted Sordan grass in a small salt-affected field with barely enough moisture permeability to keep a crop growing. The rancher who owned the field was unable to raise silage corn the previous year.

"Last fall, after one planting of Sordan," says Robbins, "the field produced an average of about 20 tons of Sordan grass per acre, which the rancher cropped and put in his corn silage pit. This was an area in which he had not been able to raise anything of value because of a high sodium-to-soil ratio."

Robbins believes that planting Sordan grass may be the cheapest, most effective way to reclaim salt-affected soils while providing an abundant source of silage for livestock.

To offset the effects of salt and reclaim marginal soil, Robbins says, dryland farmers sometimes have to apply anywhere from 10 to 50 tons per acre of gypsum, a mineral form of calcium sulfate.

"At $65 to $70 a ton for gypsum, it is an expensive proposition anytime," says Robbins. "But where farmers have to truck in the gypsum, the cost of transporting, grinding, and applying it becomes prohibitive."

Robbins observes that when Sordan grows vigorously, its roots also give off formic acid and acetic acid, which dissolve still more calcium than that dissolved by the carbon dioxide, further speeding soil reclamation. "In fact, we are getting surprisingly better results by planting Sordan than we got by applying gypsum," he says.—**Howard Sherman**, Albany, CA

Charles W. Robbins is in Soil Management and Water Quality Research, Snake River Conservation Research Center, Route 1, Box 186, Kimberly, ID 93341. ■

Genetic Challenges Abound in Potatoes

Single cells from potato plants that are difficult to cross are being fused to overcome major barriers to breeding better potatoes. Cell fusion is a new recourse for solving potato-breeding problems caused by infertility, cross incompatibility, or different numbers of chromosomes, says John P. Helgeson, an Agricultural Research Service plant physiologist at Madison, WI.

Cross incompatibility occurs when the parts of a potato flower "somehow recognize that pollen landing upon it is foreign and rejects it." This problem often shows up in potatoes native to Mexico and Central America as well as in some South American species, especially wild species with important traits such as pest resistance. Many of these plants have 24 chromosomes carrying the genes that transmit inheritance.

By contrast, most varieties grown by the $1.7 billion U.S. potato industry have 48 chromosomes.

Overcoming incompatibility or chromosomal mismatches that thwart crossing is necessary if plant breeders are to improve domestic potatoes with foreign genes that transmit such traits as disease resistance or hybrid vigor, Helgeson says.

Last year, Helgeson achieved one of the world's first cell fusions of domestic potatoes, overcoming longstanding problems of infertility and cross incompatibility. He is now working with the products of five fusions of cells from wild and domestic potatoes.

According to Helgeson, offspring of these fusions will "keep several researchers busy for a long time, either deciphering the new potatoes' genetic makeups or transferring desirable genetic traits into domestic varieties."

To fuse cells, Helgeson starts with leaves taken from small potato shoots grown in nutrient solution. The leaves are then conditioned in the dark to starve them of starch. Next they are placed in an enzyme solution that dissolves cell walls, resulting in protoplasts.

Since this treatment kills many cells, Helgeson employs a fluorescent dye to identify survivors. They are put into a beaker of chemicals that neutralize electrical charges, preventing the cells from repelling each other and thus facilitating close contact.

"Only about 1 percent of some 10 million cells floating around in that soup will adhere, fuse, and mix their genes," Helgeson says.

Helgeson grows the genetically new individuals in a culture medium where they divide and produce shoots for propagation, first in test tubes, then in pots. The entire process, from leaf tips to shoots, takes about 6 months.

Potato plants bred by cell fusion, Helgeson says, are generally bigger and stronger than either parent, thus exhibiting superior hybrid vigor. Some may be the result of the fusion of four or five cells with complicated parentages.

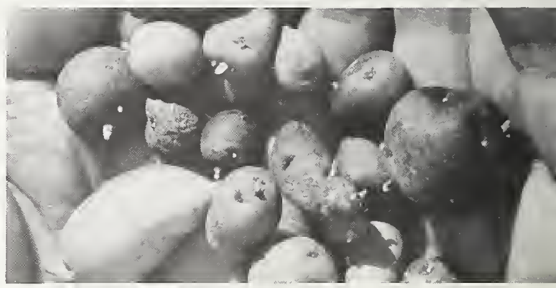
"Understanding the genetics of these plants will take time, with many questions to answer," Helgeson says. "For example, have new proteins been formed? Will desired traits be expressed or suppressed? Will traits initially exhibited persist? Why did fusion of yellow-skinned and red-skinned parents produce a black-skinned potato?"

Helgeson fused cells drawn from one of the world's premier collections of potato germplasm—about 3,500 strains, including 110 wild species—maintained at the ARS Inter-Regional Potato Introduction Station, Sturgeon Bay, WI.

Endosperm Balance Numbers...

Another technique for crossing many genetically incompatible potatoes was developed several years ago by station colleagues. Plant breeders had long known that crossing certain potato species causes a seed tissue called endosperm to dysfunction or abort.

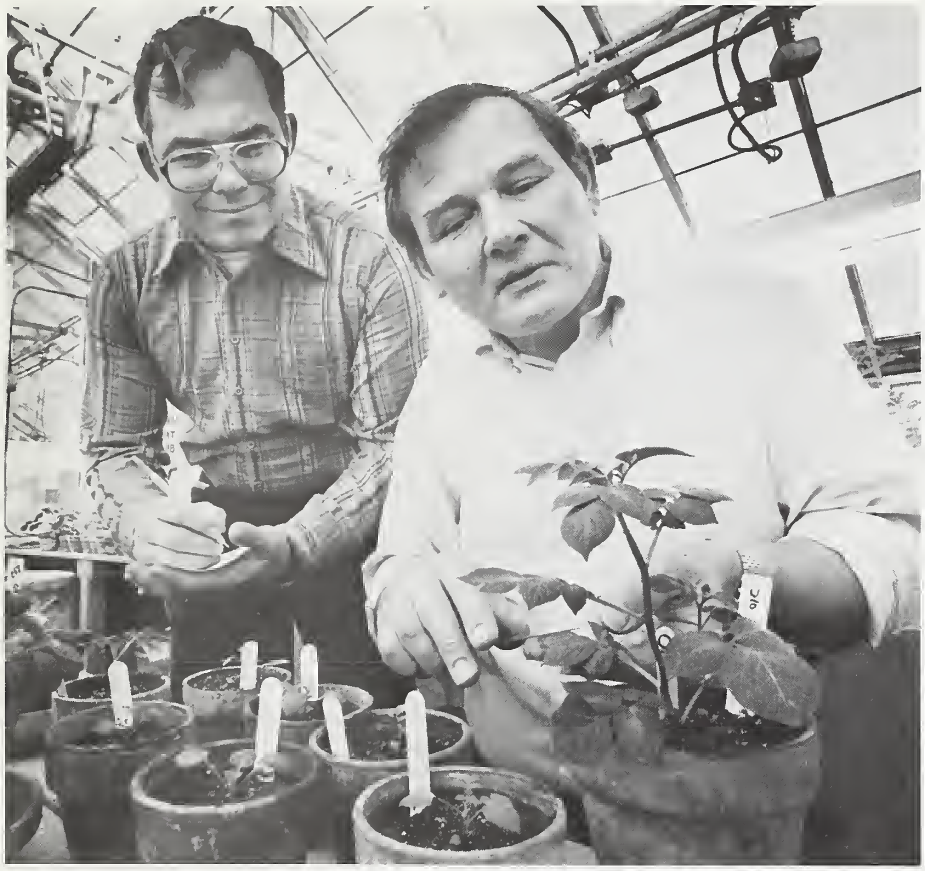
A solution came when Stephen A. Johnston, a University of Wisconsin graduate student working under the direction of Robert E. Hanneman,



Above: These tiny wild potatoes are all from the same introduction variety. They demonstrate the genetic diversity that provides potato breeders with larger gene pools. Sometimes, however, wild species cannot be crossed with domestic potatoes because they may have a different number of chromosomes. Cell fusion provides a means of overcoming such genetic obstacles. (0578X581-35A)

Top: Plant physiologist John P. Helgeson inspects potato shoots growing from tissue cultures that resulted from cell fusion of two different species. Each of the containers holds from 40 to 50 shoots which when rooted will become individual potato plants. (1284X1837-3)

ARS plant geneticist, arbitrarily assigned an Endosperm Balance Number (EBN) of 2 to a 24-chromosome South American potato when it produced offspring freely after being



In a University of Wisconsin greenhouse, geneticist Robert E. Hanneman (left) and John P. Helgeson examine potato plants produced by cell fusion. (1284X1836-17A)

pollinated by another species assigned the same balance number, regardless of how many chromosomes it had. Matching EBN's provides a systematic approach to solving the endosperm dysfunction problem.

After trying different combinations, the researchers identified EBN's for 80 of 110 wild species in the station's collection.

According to Hanneman, the Endosperm Balance Number concept can save "an incredible amount of time." A recent European breeding project required about 10,000 crosses to obtain the needed new germplasm, keeping a scientist busy over an entire pollinating season. Utilizing EBN's, the scientist could have made 25 to 50 pollinations in less than a half hour, providing the desired germplasm, he says.

The 2n Gamete Technique...

Hanneman says another breeding tool, using a pollen grain or egg called the 2n gamete in combination with EBN's, enables breeders to move genes from a species with a low chromosome number to one with a higher chromosome number. The 2n gamete pollen, easily identified because of its larger size, does not go through normal cell division; hence it retains the same chromosome number as its parent.

To explain the practical use of the 2n gamete, Hanneman cited making a cross between a species with 24 chromosomes and an EBN of 2 and one with 48 chromosomes and a balance number of 4. It produces offspring with 48 chromosomes and a balance number of 4, exactly the makeup of U.S. cultivated varieties, and is thus capable of being crossed with them, he says.

The 2n gamete technique was originally developed by Hanneman and geneticist Stanley J. Peloquin of the University of Wisconsin. These and other breeding techniques permit making crosses once deemed impossible and enhance and expedite exploitation of the station's germplasm for such traits as resistance to specific diseases, insects, nematodes, and fungi as well as for cold hardiness, Hanneman says.

So diverse is the station's germplasm that many potatoes in its greenhouses and field plots only remotely resemble commercial varieties. Plant sizes range from tall to squat; leaves differ in shape, size, and texture; and flower colors come in red, blue, purple, or a combination of these, not the almost universal white of commercial varieties. Several Chilean species even lack tubers, the edible part of potatoes, but carry valuable genes for cold hardiness and virus resistance, Hanneman says.

The Sturgeon Bay station collects and shares germplasm with plant breeders working anywhere to improve the low-cost, nutritious potato's status as the world's No. 4 food crop. One overseas project with far-reaching implications for easing hunger is extending the normal range of potatoes beyond temperate regions to undeveloped lands that are hot and humid.

"Breeding hot-weather potatoes will have to be done thousands of miles away," says Hanneman, "but some of the necessary germplasm could come from this collection."—**Russell Kaniuka**, Beltsville, MD.

John P. Helgeson is located at the Plant Disease Resistance Research Unit, USDA-ARS, Department of Plant Pathology, and Robert E. Hanneman, Jr., is at the Oats, Vegetable, and Forage Research Unit, USDA-ARS, Department of Agronomy/Horticulture, University of Wisconsin, Madison, WI 53705. ■

National Soil Lab Committed to Conservation

Studying sediment transport and deposition, technician Paul Van Holbert injects dye into water flowing from rain simulator. The dye permits measurement of velocity changes along concave study area. Depth of sediment deposited is measured by computer every 10 minutes. (1183X1558-9A)

When a raindrop strikes bare soil, some of that soil is dislodged in a miniature explosion.

When enough raindrops collect for water to run off the surface, soil is also detached as water runs downhill. Unlike the action of a single raindrop, runoff water transports some of the loosened soil and deposits it someplace else.

Further, water rarely runs downhill in a uniform sheet, but wriggles into paths of least resistance, cutting little channels, or rills, into the soil. Inside the rill, the water flows with increased energy, cutting channels deeper and deeper.

These familiar, even mundane, effects of rainstorms on soil are a matter of intense interest to the scientists who staff the 3-year-old National Soil Erosion Laboratory on the campus of Purdue University at West Lafayette, IN. A facility of USDA's Agricultural Research Service, the laboratory provides "a center and a focus" for the Department of Agriculture's soil erosion research in various sections of the country. The man who so describes the lab is its director, Harold L. Barrows, who says that his staff shares a deep commitment, not only to increasing fundamental knowledge about soil erosion, but also to the specific goal of reducing erosion on agricultural and other important lands.

At least one-third of the cropland in the United States, he points out, is currently eroding at rates faster than the soil can be replaced through natural processes of regeneration.

"In parts of Iowa," Barrows reports, "farmers are losing 2 bushels of soil for every bushel of corn they grow. Soil deficits of such magnitude can't be allowed to continue."

But he knows that farmers have to make a living and that they frequently can't afford to apply expensive

conservation measures, like terraces.

"The typical farmer very much wants to protect his resources, but he's got to pay his bills, too," Barrows says. "It's up to us to help develop improved farming systems that protect soil and water without costing an arm and a leg—systems that also produce high yields for the farmer."

Barrows points out that scientists at the laboratory work closely with other ARS and state scientists, and it is this continued cooperative research effort that will eventually pay off in reduced erosion.

Revising the USLE

In 1965, some 17 years before the soil erosion lab was dedicated in January 1982, Walter H. Wischmeier, an ARS research statistician who worked on the West Lafayette campus, first published, along with D.D. Smith, the Universal Soil Loss Equation. It was based on data from runoff plots in 49 locations around the country. The USLE, as it is called by conservationists and scientists, has been modified from time to time, and it is still the primary tool for estimating erosion for the National Resources Inventory, a survey conducted periodically by USDA's Soil Conservation Service.

The USLE is used to estimate average annual soil erosion in a given field. Variables in the formula include the erodibility of the soil; erosivity of rainfall; length and steepness of the slope; and factors for cover, management, and any supporting conservation practices used, such as terracing or contouring. Developed for areas east of the Rocky Mountains, the USLE has proved a remarkably useful tool in estimating cropland erosion in the East and Midwest. It has not performed as well in the West, however, or on long, flat slopes of the Mississippi Delta.

"Some conditions were outside the range of data used to develop the USLE," says hydraulic engineer George R. Foster, who is helping coordinate an update of the USLE and a revision of the handbook on the USLE, *Predicting Rainfall Erosion Losses.*

Foster points out that scientists are using a combination of new theoretical and experimental approaches, better data, and computers to develop more sophisticated methods for predicting erosion under more varied conditions than the USLE.

The erosion prediction method of the future, he adds, will look beyond a single land profile and permit a three-dimensional evaluation of soil erosion and movement on a whole field. Jai-Yai Lu, a hydraulic engineer who recently joined the soils lab, will devote his efforts to this work.

"A comprehensive new prediction formula is only 5 years away," says Foster, "and we hope it can be used in more parts of the world than the USLE has been."

"Just Another Material"

Teams of scientists representing several disciplines are using fresh approaches to study old questions.

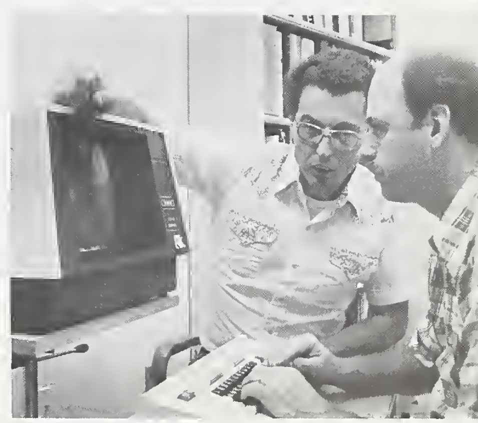
One new approach is to study soil like any other engineering material. Soil scientists have long been interested in the origins of soils, in their chemistry, and in the rich microbial life that abounds in agricultural soils.

"The trouble is that these things don't tell you everything you need to know about a soil's erodibility," comments Mark Nearing, an agronomist with a graduate degree in geotechnical engineering. "There's another way to look at soil—a cold, practical way—as just another material, like steel or concrete. We are using standard testing procedures to determine the relative strengths of different soils. We can determine each soil's mechanical resistance to a force without knowing anything about its pedigree."

Nearing says that his group, which is headed by soil scientist Joe Bradford, wants to learn more about three phenomena: the resistance of soil to the impact of a single raindrop, resistance to surface flow of water, and resistance to a combination of the two erosive actions.

A Drop Falls

A single drop of water falls from a 40-foot tower and strikes a sample



Top: Soil-laden water droplets erupt from the impact of a single raindrop striking wet soil. (PN-7152)

Middle: In west Tennessee, a gully forms on unprotected cropland after a brief, but heavy, rainstorm. Conservation tillage could help protect some fragile soils; other cropland should be put back into pasture. (0582X526-28A)

Lower: Scientist George R. Foster shows engineering graduate student Larry Brown new runoff data that may contribute to changes in the Universal Soil Loss Equation. (0984X1404-14)

Early model rainfall simulator, built in 1957, is still used by scientists in field to collect data on soil losses under different conditions of slope and rainfall intensity and duration. (1183X1555-11A)

of soil in the basement of the laboratory. Soil displaced by the splash is trapped in a ring around the soil sample so that it can be weighed and the amount removed determined.

"On some soils, three times as many particles are detached as on others," says Nearing. "We're beginning to learn what makes one soil erode so much more than another."

Also under study is the formation of crusts on a soil's surface after a heavy rain. Crusts usually reduce erosion for a time, but they also cut down on the infiltration of water by sealing off pores in the soil and produce more surface runoff. This, in turn, can create more erosion.

Another approach to understanding erodibility is being carried out by soil scientist Darrell Norton, who is exploring soil mineralogy. His staff dries soil samples in an oven and saturates them with epoxy resin so that they can later slice thin sections of undisturbed soil for Norton to study in an image analyzer.

Norton is also looking at the relation of soil erodibility to soil chemistry. It is known, for instance, that certain chemicals, like calcium, improve soil structure, while others, such as sodium, have a destructive effect.

Still another approach will be explored by Diane Stott, a soil microbiologist who recently joined the staff. She will be looking at the effect soil organic matter and biological activity have on soil erodibility.

Simulating Rainfall

Most of the heavy volume of data used by the laboratory is produced from simulated rainfall on field test plots and on plots inside the lab. ARS researchers at Purdue built their first operational simulator in 1957, and it is still being used today. A modern version designed and built at the laboratory can reproduce rainfall intensities varying from 1 to 5 inches per hour.

A major user of the data is agricultural engineer Howard Neibling, who is leading research on the mechanics of soil transport and deposition by overland flow. This research requires thousands of observations and detailed analysis of the size and weight of soil particles moved by the runoff.

Many of Neibling's findings will be used to create improved mathematical/computer models of erosion.

Reducing Erosion Is Goal

Responsible for keeping the lab's diverse activities on track is research leader William C. Moldenhauer. One of the right tracks, as far as he is concerned, is to find more effective and economical ways to reduce soil erosion.

A longtime foe of the moldboard plow and clean-tilled fields, Moldenhauer is convinced that the most important single factor in bringing Corn Belt erosion under control is to leave enough residue from a previous crop on the surface of the soil to protect it.

For example, on soils with only a 2-percent slope, planted in continuous soybeans, Moldenhauer found that simulated rainfall produced soil losses from fall-plowed or chiseled areas that were three times as great as from no-till areas.

He also found that soils on a 2.5-percent slope eroded at rates 18 times higher under a plow disk tillage than under no-till.

"What counts most in the Midwest," he says, "is the amount of residue that remains after spring planting, because it is during the next 2 months that you get the most rain and the most intense rain."

How much residue? "The more, the better," says the scientist. "But even covering 30 percent of the surface of many soils can result in 60-70 percent less erosion than on soils with no mulch at all."

As Moldenhauer and his associates collect data on erosion rates for all kinds of tillage, there is little doubt that the least soil erosion occurs with no-till, in which a cover crop is killed by a herbicide and seed for the new crop is planted in the stubble and residue of the old.

Soybeans continue to be a problem crop, however. Compared with corn or wheat, soybeans leave little residue, and even that falls apart when disturbed. One answer, finds Moldenhauer, is to seed a cover crop into a soybean crop just before harvest to hold the soil down when the beans are gone. The cover crop, which may be legumes, grasses, wheat, or rye, is killed with a contact herbicide in the spring and the new crop planted into the residue.

"We are finding practical answers to erosion, and many enterprising farmers are finding answers, too," says the scientist. "What's more, we are discovering ways to make conservation tillage more efficient, and this will give a farmer an economic incentive to adopt these improved systems. He's going to have to have systems that pay their way before he gets very enthusiastic."

Providing Technology "Packages"

The most promising medium of the future for communicating research findings to soil conservationists and farmers is the computer, says George Foster. "The Soil Conservation Service asks us for better models for predicting soil erosion and sediment yields," says Foster. "The trouble with better models, of course, is that they are also more complex than the old ones. They are harder for the field conservationist to apply. One good answer to *that* problem is to package the new erosion model in a computer program that is "user friendly." Another new employee, Charles R. Meyer, a computer specialist, will be working on this project.

Technician Dan McCracken measures soil acidity as part of study to determine electrochemical properties of soil in relation to erodibility. (1183X1573-35)

"A computer program is an excellent way to transmit expanding technical information to technicians and lay people," Foster says. "Better yet, we can use computer graphics that will show a field man or a farmer the results of his actions—pictures of stunted cornstalks and inches of soil disappearing." He believes computer programs can prove much more exciting for the user than getting the same information from a handbook.

"We've got so much to tell people," he says. "The Agricultural Research Service has the best data base of any natural resource agency in the United States, and we need to be more creative in finding new ways to communicate that information to people who can bring erosion under control."

To help communicate research results, USDA's Soil Conservation Service has assigned agronomist Ernest A. Hintz to the erosion lab. Not only does Hintz pass on results of research to SCS, but he also relays the conservation agency's research needs to ARS scientists at the laboratory.—**Hubert Kelley**, Beltsville, MD.

The scientists mentioned in this article are located at the National Soil Erosion Laboratory, South Russell and Nimitz Dr., Purdue University, West Lafayette, IN 47907. ■

Speedy Genes Enhance Plant Breeding

Genes that cause commercial crops to sprout flowers too early are very undesirable in most cases. But Edward J. Ryder, with ARS at Salinas, CA, has turned one of these "bad" genes into a valuable tool to speed up plant breeding.

Ryder concluded that plants containing early flowering genes could be used in a backcrossing program to transport desirable genes and reduce the time required to reach plant-breeding goals. Ryder's goal, in this case, was to transfer lettuce mosaic resistance into a mosaic-susceptible commercial variety known as Prizehead.

To start, he selected early flowering plants from a cross between two breeding lines that contained a gene for lettuce mosaic resistance.

These plants were used in a backcrossing program consisting of six backcrosses to Prizehead. Normal flowering plants of Prizehead were used as the recurrent parent in the backcrossing.

Chosen as the other parent for backcrosses were the early flowering plants containing the mosaic resistance from the preceding backcross. Two types of early flowering plants were produced in each generation, but only one of them contained the gene for mosaic resistance.

From the sixth backcross, which was 98 percent like the original Prizehead, only normal flowering plants were selected.

The early flowering plants used in the backcrosses bloomed in an average of 63 days compared with a 120-day average for normal flowering plants.

Ryder says, "To achieve maximum speed, I backcross both types of early flowering plants from the previous generation and later identify the ones containing the gene for mosaic resistance. I did not interrupt backcrossing to grow selfed progeny in order to select plants resembling Prizehead, the recurrent parent type."

Geneticist Edward J. Ryder (right) and technician Bert J. Robinson observe differences between spindly, early-flowering lettuce and normal lettuce. Genes that cause early flowering enable faster development of improved lettuce varieties for consumers. (0584X633-9)

Because normal flowering Prizehead plants were used as the recurrent parent, Ryder says, they had to be planted 60 to 80 days ahead of the early flowering progeny of the crosses in order to achieve coincidence of flowering.

The entire process required 550 growing days. Had Ryder induced the mosaic resistance through conventional backcrossing, it would have taken 875 days. All work was done in the greenhouse to avoid seasonal interruptions.

Lettuce mosaic is caused by a virus that is transmitted through the seed. It can be controlled by protecting and testing the seed, but use of

resistant varieties for control is less subject to human error, Ryder says.

Ryder and coworkers at the research station developed the first U.S. iceberg lettuce varieties resistant to mosaic disease, but before the early flowering gene was put to use.

Ryder got the idea for the speedy gene technique when he noticed that some lettuce plants he was growing in greenhouse pots suddenly took off, bypassed the foliar production stage, and produced flowers in about 45 days. Normal lettuce plants produce flowers in about 120 days.

"The beauty of the technique," Ryder says, "is that the early flowering is caused by a partially dominant gene, so it can be used to transport any desirable gene from one variety to another. Moving wanted genes with early flowering can be used on any plant species that has dominant or partially dominant early flowering genes."

Ryder cautions that the technique is more useful when the inheritance is simple (one gene) than when the inheritance is complex (two or more genes). It can be used, however, when inheritance is complex if the genes can be identified.

The most obvious importance of this technique is the general reduction in breeding time for new varieties, Ryder says. But its most important use could be in developing resistant varieties of plants to avert a threatened disaster by insects or diseases.—**James Whorton**, Albany, CA.

Edward J. Ryder is located at the U.S. Agricultural Research Station, 1636 E. Alisal St., P.O. Box 5098, Salinas, CA 93915. ■

Major Step Toward Poultry Coccidiosis Vaccine

Secretary of Agriculture John R. Block, at a March 18 press briefing in Washington, announced encouraging test results from a genetically engineered antigen that could become a key to developing a vaccine against coccidiosis, a disease which costs the poultry industry $300 million a year.

"The new experimental antigen confers the first protection ever obtained against any species of coccidia by any method other than inducing actual infection," Block said.

Block cautioned that the protection was not complete but called the results "highly encouraging." He added that global research efforts to produce a vaccine based upon either dead coccidia or antigens made from them had met with failure.

According to the secretary, the research is "a good example of how USDA scientists and industry come together to solve agricultural problems."

Orville G. Bentley, assistant secretary for science and education, said the antigen was engineered by Russell McCandliss and colleagues at Genex Corp. of Rockville, MD, using antibodies produced by the Agricultural Research Service.

ARS scientists will work with Genex to turn the antigen into a vaccine for the poultry industry, Bentley said.

"This biotechnology research," he said, "is typical of USDA projects being conducted at a number of locations."

According to Bentley, coccidiosis costs the poultry industry $200 million a year in deaths and debilitation of chickens and turkeys and an additional $100 million a year for ongoing medication of broiler flocks.

Coccidia are parasites that attack a fowl's intestinal tract, either causing death or debilitating the bird through weight loss due to improper utilization of feed. They also cause a paler skin color.

Bentley said efforts to develop the antigen began in 1982 with production of antibodies at ARS' Animal Parasitology Institute at the Beltsville, MD, Agricultural Research Center.

Agency scientists produced the antibodies using hybridoma biotechnology, Bentley said. A hybridoma is a hybrid cell that acts like a factory to produce large quantities of a specific antibody against a disease-causing agent.

Microbiologists Harry D. Danforth and Patricia C. Augustine said they took antibody-producing spleen cells from mice that had been injected with coccidia and fused them with mouse cancer cells growing in cultures. What resulted, Danforth said, was a hybridoma that combined monoclonal-antibody-producing ability with longevity.

Danforth and Augustine said that after cloning, the hybridomas continued to divide and produce antibodies in volume.

With a large supply of monoclonal antibodies on hand, ARS advertised for and competitively selected commercial firms in July 1982 to produce genetically engineered antigens using the antibodies.

Terms of the agreement called for ARS to furnish antibodies and other assistance to the firms. The firms, in turn, agreed to supply genetically engineered antigens to the agency for testing. ARS and Genex scientists found that injecting chickens with the experimental antigen stimulated production of the antibodies.

The bioengineered antigen provided partial protection against clinical infection by one major species of coccidia, Danforth said. "Among infected birds, those that got the antigen grew better than those that did not but not as well as those that were free of disease," he said. "This finding is based on results involving weight gain, feed utilization, and severity of infection."

Further testing is required, he said, to determine if protection can be made complete. Additional tests will be made to show whether the same approach is effective against other species of coccidia and to establish the best method for giving the antigen.

"Obviously, more work is needed before we reach the ultimate goal of a practical vaccine for coccidiosis," Danforth and Augustine said. "But we are pleased to achieve an important milestone in progress toward nonchemical control of this parasitic disease."—**Russell Kaniuka**, Beltsville, MD.

Harry D. Danforth and Patricia C. Augustine are located at the Animal Parasitology Institute, Bldg. 1040, Beltsville Agricultural Research Center-East, Beltsville, MD 20705. ■

High-Protein Rice Flour From Enzyme Treatment

A new rice flour, three times richer in protein than standard rice flour, could help reduce malnutrition among children in less developed nations, says an ARS food chemist.

Linn P. Hansen, developer of the enriching process, says the new rice flour has 25 percent protein compared with 8 percent in standard rice flour. Hansen says that

Food chemist Linn Hansen with containers of standard-process rice-flour (left) and chemically high protein rice flour. The CHP-flour has 3 times the protein content of standard rice flour. (0285X142-32)

in addition to having twice the protein of wheat flour, the new rice flour contains more of the amino acids essential in the human diet.

Named CHP (chemically high protein) rice flour, the new flour can be produced from standard rice flour using an enzyme obtained from *Aspergillus oryzae*. This enzyme is already commonly used in the food-processing industry, Hansen says. Standard rice flour is used as a raw material because, being made from broken grains, it is less expensive than whole-grain rice on domestic and world markets.

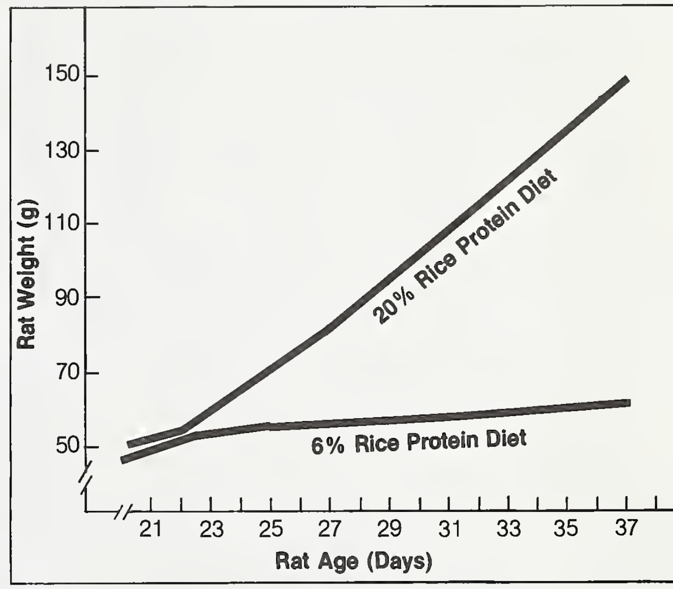
The laboratory process for making CHP-rice flour involves gelatinizing a 5-percent flour slurry by heating for 30 minutes at 100° C. The temperature is then lowered to 37° C and the enzyme added. After the enzyme works for 30 minutes, the material is filtered or centrifuged to separate the solids—which contain the protein—from the liquid. The solids are freeze- or drum-dried to produce the finished product. The remaining liquid contains maltose-type sugars which can be used to culture yeast to further fortify the rice flour if desired, Hansen notes.

This process results in a creamy white powder that exceeds the protein recommendations of the World Health Organization and the United Nations Children's Fund, Hansen says. These groups recommend a 20-percent protein content for vegetable weaning foods that are fed daily in 100-gram portions. "A combined serving of 95 grams of CHP-rice flour and 5 grams of dried yeast would contribute substantially to meeting the daily protein and vitamin needs of children," Hansen says.

Human nutritional studies and food safety tests have to be conducted on CHP-rice flour before it can be marketed, Hansen says. Feeding studies with laboratory animals have been most promising, however. Weanling rats fed CHP-rice flour grew three times as fast as littermates who consumed standard rice flour.—**James Whorton**, Albany, CA.

Linn P. Hansen is located at the Cereals Research Unit, Western Regional Research Center, 800 Buchanan St., Albany, CA 94710. ■

These two laboratory rats are the same age; the larger one was raised on a diet of CHP- rice flour, while the smaller one was fed a diet of unprocessed rice. (PN-7150)



(PN-7151)

New Instrument Measures Dry Matter in Onions

A new instrument measures the quality and dry matter of onions through spectrophotometry, a process that exploits the interaction of chemicals and light.

The instrument, which does not damage the onion, has several practical applications, according to ARS chemist Gerald G. Dull and engineer Gerald S. Birth, with the Russell Research Center in Athens, GA. It can be used, for example, to separate onions high in dry matter from those low in dry matter. The low-dry-matter onions, which tend to spoil faster, could then be marketed first.

The "onion meter" can also be used to screen large numbers of onions quickly to select those with desired qualities for breeding purposes.

The instrument makes use of the fact that the skin of an onion is not completely opaque and will transmit about 1 percent of the light directed at it. Salient data, which are collected and analyzed by a small computer, are derived from the radiation that the onion does not absorb.

"The green of a leaf and the yellow of a squash are perceived because the wavelengths of those colors are not absorbed," Dull explains. "After many trials using special glass filters, we discovered that a wave-length just slightly longer than red light will measure the dry matter of onions. This is a wavelength rarely used in spectrophotometry."

The scientists point out that the quality of onion flavor is a highly complex matter, involving a number of volatile sulfur compounds and sugars. However, the concentration of sugar and the amount of dry matter in an onion are sufficiently related to allow the onion meter to measure sweetness, an aspect of onion quality that is generally evaluated subjectively or through some destructive means that involve cutting the onion. The scientists have research in progress to refine the light technique to measure specific sugars.

The onion meter is one result of Dull's research team's efforts to find nondestructive ways to measure the quality of many other horticultural crops.—**Bennett Carriere**, New Orleans, LA.

Gerald G. Dull and Gerald S. Birth are located at the Richard B. Russell Research Center, P.O. Box 5677, Athens, GA 30613. ■

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Polymer Additives for Lubricants

A new process has been developed to prepare α-substituted acrylic acids in large quantities with both high yield and purity. α-Substituted acrylic acids are useful in making polymers and hypoglycemic agents.

Production of α-substituted acrylic acids is accomplished by a process wherein a carboxylic acid is condensed with 2-amino-2-methylpropanol (AMP) to obtain an oxazoline. The reaction mixture is neutralized, and oxazoline is converted to a methylol derivative with para-formaldehyde. The intermediate derivatives are heated with an azeotrope, such as xylene, to obtain an α-methylene oxazoline which is hydrolized to afford the α-substituted acrylic acid. Fatty acid is removed as the methyl ester.

For further technical information, contact Samuel Serota, Eastern Regional Research Laboratory, 600 E. Mermaid Lane, Philadelphia, PA 19118. *Patent No. 4,477,384, "Preparation of α-Substituted Acrylic Acids."*

Improving Baking Quality of Unbleached Flour

A patented process enhances the baking quality of unbleached cake flour. Currently, cake flour is bleached with chlorine gas to improve the eating quality of pastries made from the flour. Treatment with this chemical can be avoided, according to the inventors, if wheat flour is heated to 120°-200° F (49°-93° C) and held at that temperature for a specified length of time.

The length of time required for heat treating varies from 1 hour to 10 weeks, depending on the temperature. Ultimately, wheat can be simultaneously ground and heated to obtain improved performance.

Additional benefits can be obtained under the process by treating starch with excess water and holding at a temperature of 129°-160° F (54°-71° C), long enough to swell the starch granules but not cause them to fragment.

For further technical information, contact Maura M. Bean, Western Regional Research Center, 800 Buchanan St., Berkeley, CA 94710. *Patent No. 4,157,406, "Process for Improving Baking Properties of Unbleached Cake Flour" and related Patent No. 4,259,362, "Process for Improving Baking Properties of Unbleached Flour."*

High-Protein Flour From Cottonseed

A simple, air-separation process produces high-protein flour from glanded cottonseed. The new edible flour contains 65 percent protein and has chemical and physical characteristics that make it attractive for use in food products. It also meets standards for free gossypol content of both the U.S. Food and Drug Administration and the Protein Advisory Group of the United Nations.

Cottonseed products made from glanded cotton normally contain a chemical—gossypol—which cannot be eaten by humans or nonruminant animals unless it is chemically treated.

ARS scientists at the Southern Regional Research Center have prepared an engineering analysis of technical and economic factors that should be considered by persons interested in obtaining a license to make the new flour. The analysis is updated on a continuing basis to reflect current market prices and costs.

For further technical information, contact Ranjit S. Kadan, Southern Regional Research Center, P.O. Box 19687, New Orleans, LA 70179. *Patent No. 4,201,709, "Process for Producing a Low Gossypol Protein Product From Glanded Cotton."*